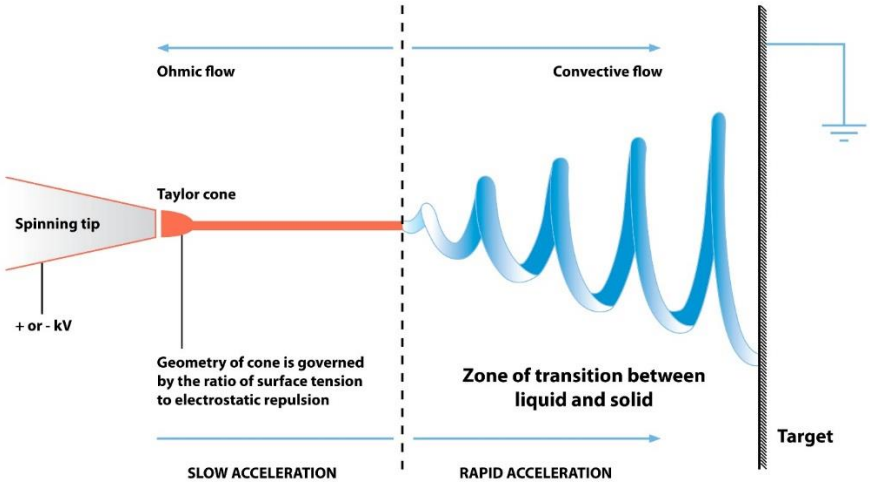
Field Controlled Direct-Write Electrospinning

Context and Benefits: Electrospinning is rapidly becoming a popular technology with a myriad of applications in many different fields and industries. Fibers with a nano-scale width, or nanofibers, exhibit a high aspect ratio and provide a very large degree of anisotropy, which enhances energy transfer efficiency and other beneficial parameters in many technology fields, such as thermoelectric, photoelectric and RF/microwave applications. Electrospun nanofibers can be greatly superior in these fields when compared to bulk materials.

By nature of electrospinning, the deposition of electrospun fibers are random in orientation due to the instability of the convective flow stage of fiber formation, as shown in Fig. 1. It is during this stage that bends develop throughout the length of the fiber, where electrostatic repulsion results in rapid, random spatial orientation before the fiber settles on the collection target.



Many different approaches have been developed in directing and aligning electrospun nanofiber. Rotating collectors allow the fiber to be pulled radially to create a degree of alignment, but very high rotational speeds are required as the fiber gets thinner and stray fibers still could not be eliminated at the very high speed. Specific collector geometries also allow for anisotropic alignment of the fiber, but the distribution of deposition across the entire collector is often uncontrolled. Other methods involve targeting the electrospinning spray to a specific point. These single point electrodes allow for “writing” with electrospun fiber, where tight geometric patterns can be created. Current methodologies, however, dictate that in order to direct the pattern, either the point electrode move, or the collector stage move relative to a fixed electrode. This mechanical movement creates a variety of problems. In addition to limitations of scale, the mechanical movement of the system would have to be very fast (up to 1Km/s) if one wanted to create straight, aligned nanofiber of a small diameter. The movement speed limits how thin the nanofiber can be drawn, restricting the number of potential applications for the technology.

Our field controlled direct-write electrospinning technology fills these deficiencies. It involves directing electrospinning targeting by manipulating the electrical status of components in the system to control electrical field geometry, rather than mechanically moving the components affecting/affected by the field. This allows for much more rapid control of the field, creating the potential for straight, highly

anisotropic deposition of nanofiber at thicknesses not possible with other methodologies. And in combination of some simple stage movements, more complicated pattern of deposition could be created.